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NOTES AND LITERATURE

IS THE FEMALE FROG HETEROZYGOUS IN REGARD TO SEX-DETERMINATION?

THE evidence that sex is determined by an internal mechanism in unisexual animals has accumulated rapidly in the last few years. The one outstanding case is that of the frog. That extreme variations in the sex ratio occur in this amphibian has been evident from the early experiments of Born 1881, Pflüger 1882, and Yung 1883-85. The effects were generally ascribed by the earlier workers to differences in the food of the tadpole. Most recent and more carefully controlled experiments, notably those of Cuénot and of King, have shown beyond doubt that food is not a factor that determines the sex of the tadpole. On the other hand, Richard Hertwig has effected astonishing changes in the sex ratio of the frog by delaying fertilization of the eggs. Over-ripe eggs produce a high percentage of males. This conclusion has been recently confirmed and extended by a student of Hertwig's, Sergius Kuschakewitsch.¹ By delaying fertilization of the eggs for 89 hours after the first eggs had been laid (which gave 53 per cent. of males) there was produced 100 per cent. of males. The death rate of the larvæ was so low (from 4 to 6 per cent.) that it could not have seriously affected the results. The following table gives the outcome of Hertwig's observations and those of Kuschakewitsch.

Author	Hours 0	Hours 6	Hours 18	Hours 24	Hours 36	Hours 42	Hours 54	Hours 64	Hours 89
R. Hertwig, 1907	58%	54%	—	55%	—	—	87%	—	—
“	49	—	—	—	58%	—	59	—	—
“	48.5	—	37%	—	—	50%	—	88%	—
Kuschakewitsch	53	—	—	—	—	—	—	—	100%

This evidence shows beyond question that the *sex ratio* is affected by delay in fertilization, and may seem to show even that *sex itself* is determined by this factor. The evidence will, however, bear closer scrutiny. The frogs, *Rana esculenta*, were captured while pairing, and were allowed to lay a few eggs in

¹ Hertwig's Festschrift, 1910.

confinement, when they were separated. After 89 hours the female was killed, the remainder of her eggs placed on glass slides, and fertilized with a decoction of the testes of other (one or more?) males. If many of the eggs soon rotated within their membranes this was taken as a sign of successful fertilization. It will be noted that a different male from that employed for the normal fertilization was necessarily employed, because the original male had presumably lost his power to further fertilize. The employment of different males introduces a possible error into the results, for, if the male is heterozygous for sex determination, it is conceivable, as I have previously pointed out in reviewing Hertwig's results, that in different individuals the sperm may be differently affected in regard to its fertilization power. At present we have no evidence to show that in male frogs such differences exist, and it seems unlikely that such consistent results as these of Hertwig and of Kuschakewitsch can be explained in this way. An alternative view is, however, possible. If the female is heterozygous for sex production, and in consequence two kinds of eggs are produced, it may be that the female determining eggs are more injured by delay than are those of the other class, the male-determining eggs. It becomes, therefore, imperative to know what proportion of eggs were fertilized in these experiments. Unfortunately this critical evidence is omitted from Kuschakewitsch's paper. He states that the death rate of the tadpoles that emerge is low, but one looks in vain for information relating to the number of eggs that were fertilized. Therefore until this datum is forthcoming it is not possible to draw any certain conclusions in regard to sex determination from the evidence published by the author.

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THE MUTATION THEORY

The publication of the first volume of DeVries's "*Mutations-theorie*" in 1901, together with the rediscovery of Mendel's principles, served to bring about a period of unprecedented activity in the study of the problems connected with variation, heredity and evolution. While the results of this decade of work have probably raised as many questions as they have answered, yet the period has undoubtedly been marked by advances of the first importance, both in methods of investigation and in